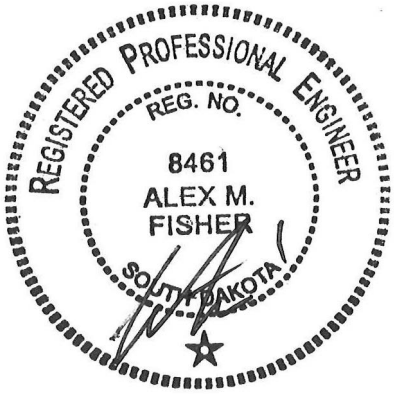
Geotechnical Evaluation

for

Hot Springs VA Hospital
Renovate Electrical Equipment
Hot Springs, South Dakota

January 15, 2024



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1. INTRODUCTION

We understand a new electrical switching building is proposed for construction to the south portion of the Hot Springs VA Hospital Campus in Hot Springs, South Dakota. The single-story, approximately 705 square foot, steel-framed prefabricated structure will include an approximate 3' to 4' below-grade level crawl space.

At the time of this report, finished floor elevations were not provided, therefore, we have assumed that a fill scenario of 0.5 feet to 2 feet within the building footprint will be required. If more than 2 feet of fill is req`uired at the site, our conclusions and recommendations contained in this report shall not be considered valid and will need to be re-evaluated and revised accordingly.

FMG Engineering was retained by Stone Group Architects to perform a geotechnical evaluation of the proposed project site to identify the subsurface conditions and suggest suitable foundation systems for the structure. If proposed construction or locations differ significantly from that described above or elsewhere described in this report, our office should be contacted to re-evaluate the recommendations contained in this report. Figure 1 indicates the locations of the boreholes drilled for the project.

1. A general review of the regional geology, and related site characteristics.

2. Field exploratory borings, sampling, and testing at representative locations to determine the depth, thickness, orientation, engineering characteristics, and composition of the subsurface conditions.

3. Laboratory tests to identify the soil types, classifications, and engineering properties of the subsurface materials encountered at the site.

4. An analysis of the data obtained, and determination of suitable geotechnical design parameters and other such recommendations as considered applicable to satisfactory design and performance.

Field and laboratory tests were generally accomplished in accordance with current ASTM and AASHTO procedures, where applicable. The evaluation was accomplished under the direction of a registered professional engineer. This report presents the geotechnical engineering evaluation with recommendations for foundation and pavement design. We have also included a discussion of our field sampling and testing procedures, laboratory analyses, and site conditions.

2. FIELD SAMPLING AND TESTING PROCEDURES

A total of one (1) borehole was drilled at the location shown on Figure 1 to identify the subsurface characteristics and obtain soil samples for laboratory testing. The borehole was observed by the FMG field geologist. Field sampling and testing procedures were conducted in general accordance with ASTM D420.

The borehole was drilled with a Diedrich D70 track mounted drill rig and hollow-stem auger. The borehole location was selected by FMG and was adjusted in the field as necessary by FMG to avoid existing utilities and respect to site access. If, during subsequent planning, the project locations change significantly from those described in this report and shown on Figure 1, we recommend drilling additional boreholes to verify soil conditions in unexplored areas.

Borehole field testing consisted of obtaining standard penetration test (SPT) and relatively undisturbed Shelby Tube samples from various depths in the boreholes. The SPT testing was performed to identify the relative field strengths of the subsurface materials and to obtain samples for laboratory analyses; Shelby Tube samples were obtained for laboratory analyses.

Geologic log of the borehole was maintained by a field geologist and the materials were classified in accordance with ASTM: D 2487-90 and D 2488-90 (Unified Soil Classification System), Figure 2. The geologic log includes the general drilling method data, depths of major changes in the character of the subsurface materials, visual description of the materials, sample locations, standard penetration data and locations, and groundwater data. In addition, the geologic log also includes data from certain laboratory classifications and physical property analyses. The geologic log is presented as Appendix A.

The geologic logs and related information depict only the conditions and materials encountered at the specific borehole location and at the time designated on the logs. Soil conditions at other locations may be different from those encountered at the borehole location. Also, the passage of time may produce a changed soil condition. We have extrapolated the data obtained from the boreholes and our conclusions and recommendations assume that the materials encountered are representative of the soils that exist over the site. Anomalies may be present around the borehole.

3. LABORATORY ANALYSIS

The laboratory analysis was directed towards the determination of soil types drilled on the site and their engineering properties. The laboratory testing was performed in general conformance with current ASTM and AASHTO procedures, where applicable. The laboratory testing results are provided in Appendix B, and on the borehole logs where applicable.

3.1 ATTERBERG LIMITS

The Atterberg limits were determined for select samples. These tests allow for more detailed classification of soils and provide information relative to the expected engineering characteristics and properties. (ASTM D4318-05)

3.2 GRAIN SIZE ANALYSIS DATA

Standard grain size analysis determinations were performed to determine the grain size distribution and assist in the determination of the physical characteristics and engineering properties of the subsurface materials. (ASTM D422-63(2007))

3.3 CONSOLIDATION ANALYSIS

Consolidation/swell tests were performed on relatively undisturbed samples that were obtained from the soil encountered at the site. The consolidation/swell test allows determination of the soil's swell pressure, percentage of swell, collapse potential, and approximate volume change potential with varying moisture conditions. The data from the consolidation/swell test can be used to develop potential uplift pressures or consolidation characteristics which may affect the performance of the foundation. (ASTM D2435)

3.4 UNCONFINED COMPRESSION TESTING

To help quantify the strength characteristics of the on-site materials, unconfined compression testing was performed on select samples. The unconfined compressive test results provide indications of the strength of the soils. Results are provided in pounds per square foot (psf). (ASTM D7012)

3.5 SAMPLE STORAGE

The soil samples obtained during this evaluation will be stored for a period of one year. If the client wishes to receive the samples arrangements should be made; otherwise, the samples will be discarded after one year.

4. SITE CONDITIONS

The new electrical switching building is proposed for construction to the south portion of the Hot Springs VA Hospital Campus in Hot Springs, South Dakota. The surface of the site is currently vacant land void of structures, except for mowed grasses, bushes, and a large deciduous tree in the center of the property. The site generally slopes away from the site to the south.

The site is bound by a gravel roadway to the north, existing buildings to the east and west, and a parking lot for the Pioneer Museum to the south.

4.1 MATERIALS PRESENT

The site stratigraphy generally consists of approximately 10.5 feet of silty lean clay to lean clay material, overlying silty gravel with sand soils to the total depths explored of 21.5 feet.

4.1.1 Material Descriptions

The silty lean clay to lean clay materials were found to be brown, dry to moist, low plasticity, and medium stiff to stiff in consistency. The lean clay soils were found to be slightly expansive, exhibiting up to 1.0% swell against a 100 psf surcharge upon saturation, with a swell pressure of 1,000 psf.

The underlying silty gravel with sand soils were found to be brown, dry, non-plastic, and dense to very dense.

The geologic logs indicate the specific soil characteristics observed throughout the profiles in each of the boreholes advanced at the site.

4.2 GROUNDWATER TABLE

A shallow groundwater table was not encountered at the site. However, groundwater presence and levels should be anticipated to vary in response to seasonal changes in precipitation, bedrock fracture patterns, high precipitation events, and snow melt, and may not be accurately delineated within the normal scope of a geotechnical evaluation.

4.3 GEOLOGIC CONDITIONS

The geologic conditions of the project site can be generally described as Terrace Deposits. The terrace deposits can consist of reddish brown, subangular to sub-rounded, cross-bedded conglomerate material. (Wolcott, 1967)

Geologic mapping of the area indicates no mapped faults or geologic structures within proximity of the project site that would impact siting, design or construction of the proposed project. (Wolcott, 1967)

5. CONCLUSIONS AND RECOMMENDATIONS

From our subsurface exploration and engineering analysis, we have arrived at the following conclusions and have the following recommendations regarding foundation design for the proposed construction. The conclusions and recommendations presented in this report do not reflect variations in subsurface conditions that are likely to exist in unexplored areas. Should such variations be revealed during construction, it may be necessary to re-evaluate our recommendations based upon on-site observation of the variations. Also, we should be retained to review the foundation plans, as well as applicable portions of the specifications when they become available.

5.1 FOUNDATION AND SLAB SYSTEM SELECTION

The subgrade beneath the proposed building consists of approximately 10.5 feet of slightly expansive, medium stiff to stiff silty lean clay to lean clay material overlying dense to very dense silty gravel with sand. The subgrade soils are suitable for a conventional frost depth shallow foundation system. The primary geotechnical concern for foundation and slab performance is potential post construction movement related to the expansive subgrade soils when subject to moisture content variation. Differential settlements on the order of 1¼ inches or more are possible if a shallow foundation system founded directly upon on-site soils is utilized.

To mitigate movements related to the expansive nature of the soil, we recommend the shallow foundations and floor slabs be constructed upon an engineered fill section. The engineered fill section should be a minimum of 12 inches in thickness below footings, crawl space, and floor slabs. Further, to mitigate differential settlements, we recommend that all fill materials utilized to achieve desired site grades within the building footprint consist of engineered fill. The engineered fill section will require some degree of over-excavation of native soils for most of the foundation layout, and over-excavation below the floor slab in portions of the building footprint. The over-excavation program and construction of the engineered fill section will serve to replace a thickness of expansive soils with non-expansive, relatively incompressible engineered fill.

Some minor movements of shallow foundations are possible due to inherent, natural variations in native soils and geologic materials. Minor movements can still result in cosmetic distress to architectural building components, floors, drywall, etc. Total movements of foundation elements may be on the order of 1 inch or less; differential movements are anticipated to be on the order of ½ inch. The design parameters and construction criteria presented in Section 5.1.1 and Section 5.1.1.1 should be observed for shallow foundation.

It should be noted that the heave values obtained from these analyses are subject to the inherent variability of the soil profile and idealized methods used in the analysis. The actual magnitude of movement that will occur beneath the foundation or floor system will depend on the inherent variability of soil mineralogy and profile, the actual in-service loading conditions, the extent to which the subgrade soils are exposed to moisture variations, and the quality of the earthwork and foundation preparation procedures.

5.1.1 Shallow Foundation and Slab-on-Grade Systems

Table 1 – Shallow Foundation and Slab-on-Grade Design Criteria

Parameter	***Value***
Subgrade Preparation	1. Over-excavation and installation of 12-inches engineered fill section below foundation elements, crawl space, and floor slabs. 2. All fill material within building footprint shall consist of engineered fill
Net Allowable Bearing Capacity (FS=3.0)	2,000 psf
Static/Dynamic Modulus of Subgrade Reaction	200 pci for engineered fill
Frost Penetration Depth	42 inches
Sliding Friction Coefficient	0.42
Passive Earth Pressure	235 psf

5.1.1.1 Design and Construction Criteria

1. We recommend all existing soils below shallow foundations, crawl space, and floor slabs be over-excavated to a minimum depth of 12 inches below bearing depth and replaced with properly compacted engineered fill. The over-excavation should extend beyond the inside and outside edges of the foundation 1 foot for every 1 vertical foot of over-excavation. See Figure 3 for an illustration of this geometry. The engineered fill should meet the requirements outlined in Section 5.3 of this report and be compacted in accordance with the soil compaction criteria provided in Table 3. The Geotechnical Engineer shall observe the over-excavation process to verify removal extents are sufficient.

2. All fill material within the building footprint shall consist of engineered fill.

3. Debris, trees, roots, fills, and other relics associated with past site developments may be encountered during excavations at the site. If encountered, such items should be removed in their entirety and the resulting voids should be backfilled with properly compacted engineered fill meeting the material and compaction requirements of Section 5.3 of this report. Relic utilities encountered during excavation efforts shall be cut, sealed, and capped at the perimeter of the over-excavation limits to prevent water ingression within the building footprint. The Geotechnical Engineer should observe over-excavations prior to engineered fill placement.

4. Care should be exercised during foundation and slab excavation as to not disturb the excavation subgrade. We recommend that an excavator with a smooth cutting edge be utilized as excavations near designed depths. Should the excavation subgrade be disturbed, we recommend that the excavation subgrade be scarified to a depth of 8 inches, moisture conditioned and recompacted in accordance with the criteria provided in Table 3 of this report prior to placement of concrete, reinforcing steel or engineered fill to provide a uniform subgrade.

5. If soft conditions are encountered at the base of the foundation or slab excavations, the excavation should be over-excavated to stable conditions as directed by the Geotechnical Engineer. As directed by the Geotechnical Engineer, the additional over-excavation should be replaced with properly compacted engineered fill or stabilization rock meeting the requirements outlined in Section 5.3.1 of this report. The engineered fill should be compacted in accordance with Table 3. If utilized, stabilization rock should be used to the extents necessary to provide a stable subgrade, above which properly compacted engineered fill should be installed up to foundation or slab bearing elevation. Any stabilization rock should be covered with a non-woven filter fabric prior to placement of engineered fill.

6. A one-third (33%) increase in allowable bearing capacity for wind or seismic cases is permitted based on reducing the factor of safety from 3.0 to 2.25.

7. Compacted fill placed against the sides of the footings to resist lateral loads may be moisture-conditioned, on-site soil. The fill should be placed in accordance with the fill and soil compaction criteria provided in Table 3.

8. Precipitation events or fluctuations in groundwater levels could cause the base of the foundation excavations to be within the range of possible groundwater fluctuations. Dewatering efforts may be necessary. It may be necessary to install sump pits and dewater the excavations to allow proper excavations, fill placement, subgrade preparation and foundation construction. We recommend that the contractor obtain the necessary permits for the dewatering operations and that the dewatering be performed in accordance with local, county, state, and federal regulations.

9. The natural soils may pump or deform excessively under the wheel loads of heavy construction vehicles as the excavations approach footing levels. Construction equipment should be as light as possible to avoid this difficulty. The movement of vehicles over proposed foundation or floor areas should be restricted. Any areas disturbed by construction traffic should be stabilized or over-excavated and replaced with stabilization rock or compacted engineered fill.

10. Where possible, floor slabs should be separated from all bearing walls and columns with expansion joints, which allow unrestrained vertical movement.

11. Floor slabs should be provided with control joints to reduce damage due to shrinkage cracking and should be adequately reinforced.

12. A positive bond break should be provided where utility lines enter through the floor. Flexible connections, oversized sleeves at wall and floor penetrations or other such mechanical controls should be provided for slab-bearing mechanical equipment. Such controls should be designed to accommodate up to 1 inch of potential movement.

13. The sub-slab engineered fill section should be extended to any exterior concrete flatwork that may be sensitive to differential or total vertical movements.

14. Materials immediately below the slab should consist of properly compacted engineered fill meeting the requirements of Section 5.3 or a free-draining gravel or sand leveling course. In no case should clay soils be placed directly below the floor slab. If floor coverings are, or have the potential to be, moisture or vapor sensitive, a vapor membrane is recommended below the floor slab. The membrane should be consistent with ASTM E1745 – Class A, or equivalent as approved by the Geotechnical Engineer.

A qualified Geotechnical Engineer should observe all footing excavations prior to concrete placement. A representative of the Geotechnical Engineer should perform compaction testing during any moisture-conditioned fill placement.

We suggest that final testing of the floor slab area be performed (in addition to testing during placement) immediately before concrete placement to determine the integrity of the materials. Severe changes in the condition of these materials can occur after initial preparation as the result of rain, drying, freezing, and construction activities. Any subgrade or foundation material that becomes disturbed, desiccated, or does not conform to the

moisture content and compaction requirements indicated in Table 3 should either be removed and replaced or reworked to meet these recommendations.

Regarding the concrete floor slab, it should be noted that Portland cement concrete is not a perfect construction material. Due to the characteristics of Portland cement concrete itself, cracking of the floor slab may occur. Cracking will be minimized, but not eliminated, by providing appropriate control, isolation, and construction joints. Drying and thermal shrinkage of the slabs with resultant hairline cracking or curling may occur if the slabs are cured under anything less than optimum curing conditions. In short, there is no practical method of ensuring that all floor slab cracking is eliminated due to the nature and performance of the Portland cement and the consolidation properties of the subgrade soils.

5.2 SITE SEISMICITY

Seismic design should be in accordance with the ASCE 7-16 seismic design parameters provided below. The Seismic Site Class indicated below in Table 2 assumes the soil conditions encountered at the bottom of the borings continue to a depth of 100 feet. A more detailed and accurate Site Class evaluation may be achieved by performing geophysical seismic surveys to develop the shear wave velocity profile for the site to a depth of 100 feet.

Table 2 – Seismic Design Criteria

ASCE 7-16 Seismic Design Parameters	
Seismic Category	C
Site Class	D
MCE Spectral Response Accelerations	
Short Period, S_s	0.211 g
1-second, S_1	0.05 g
Site Coefficients, F_a	1.6
Site Coefficient, F_v	2.4
Design Spectral Response Accelerations	
Short Period, S_{DS}	0.225 g
1-second, S_{D1}	0.08 g

5.3 GENERAL MATERIAL PLACEMENT REQUIREMENTS

5.3.1 Fill Materials

The **on-site silt and clay materials**, segregated from debris, deleterious material, and any oversized material greater that 6-inches in maximum dimension, will be suitable for use as exterior foundation backfill, utility trench backfill, and general site fill, and pavement subgrade fill. The on-site fat clay and shale fills, and shale bedrock materials will not be suitable for placement of fill within the building footprint.

We recommend that all **engineered fill** materials consist of non-expansive, well-graded natural or crushed gravel with 100% passing the 3-inch sieve and between 8% and 20% passing the #200 sieve. The engineered fill material should also have a liquid limit less than 30 and a plasticity index of less than 15.

On-site sources of **stabilization rock** were not identified. These materials will have to be imported to the site, if necessary. The stabilization rock should be a clean rock with 100% passing the 3-inch sieve, 0 to 15% passing the 1-inch sieve, and 0 to 8% passing the #4 sieve.

If necessary, **imported, non-engineered fill materials** for non-structural, general site fill areas shall have a maximum particle size of 3 inches and shall meet one of the following USCS classifications: GM, GC, SM, SC, CL. The imported fill material shall have a free swell of less than 1.0% as determined by ASTM D4546 or D2435.

5.3.2 Fill Placement

We suggest that sufficient density tests be taken by qualified personnel to indicate the degree of compaction being attained. We recommend controlling scarification, fill and backfill operations using the moisture content and dry density relationship as determined by ASTM D 1557 (Modified Proctor Density). Site fill materials, including engineered fill below foundations and slabs, should be placed in 6-12-inch loose lifts and compacted to the densities and moisture contents outlined in Table 3 below. Any additional moisture required to achieve compaction in a layer should be added and the entire lift mixed to obtain uniform moisture content.

We suggest that final testing of the footing subgrade and other fills in "structural areas" be performed (in addition to testing during placement) immediately before concrete placement to determine the integrity of the materials. Severe changes in the condition of these materials can occur after initial preparation as the result of rain, snow, drying, freezing, excessive heat, and construction activities. Any subgrade or foundation material that becomes disturbed desiccated or does not conform to the moisture content and compaction requirements indicated in Table 3 should either be removed and replaced or reworked to meet these recommendations.

Table 3 – Soil Compaction Criteria

Placement Location	***Soil Type***	***Moisture Content***	***Compaction Degree***
Scarification of Subgrade Utility Trench Backfill Foundation & Floor Subgrade Foundation/Retaining Wall Backfill Sidewalk Subgrade	Free-Draining Materials (Stabilization Rock and Sand and Gravels - Less Than 8% Fines)	Workable*	90% (ASTM D-4253)
	Cohesive Materials (Clays and Silts)	0 to +3% Optimum	92% (ASTM D-1557)
	Cohesionless Materials (Engineered fill and Sands and Gravels – More Than 8% Fines)	Workable*	95% (ASTM D-1557)
Site Grading Approx. 15 Feet Away from Structures	Cohesive Materials (Clays and Silts)	+3% of Optimum	85% (ASTM D-1557)
	Cohesionless Materials (Sands and Gravels – More Than 8% Fines)	Workable*	90% (ASTM D-1557)

*a moisture content that facilitates desired compaction.

The earthen site construction materials should not be placed on frozen ground and compaction operations should not be performed during periods when temperatures are below 25 degrees Fahrenheit. During cold weather construction periods, it will be necessary to remove frozen soils prior to placement of new fill materials. The local foundation frost depth is 42 inches.

Placement of earthen site construction materials at temperatures below 35 degrees Fahrenheit may result in frost entering the soils and making placement at the required specifications difficult. Therefore, we suggest when temperatures are below 40 degrees Fahrenheit and earthen materials are being placed below structures, that the earthen site construction materials be continuously observed and tested. If frozen materials are observed being placed below structures, we suggest that they be removed and replaced with unfrozen materials as directed by the geotechnical engineer or testing personnel.

Soils having relatively high silt or fine sand contents are often difficult to compact to the desired specifications although they may be compacted well enough to suit the intended purpose. If great difficulty is encountered during construction regarding meeting the compaction specifications, a qualified geotechnical engineer should be consulted to determine if the placement of the soils at lower densities could still provide suitable characteristics.

5.4 RETAINING STRUCTURES AND LATERAL EARTH PRESSURES

Any retaining structures on the site can be expected to deflect sufficiently to mobilize the full active earth pressure condition. Retaining walls which can be expected to deflect may be designed using the “active” earth pressures. Foundation walls or grade beams that will be laterally supported and are expected to undergo only a limited amount of deflection, thus requiring the consideration of the “at-rest” earth pressure condition.

The lateral resistance of wall foundations will be the combination of the sliding resistance of the footing on the foundation materials and the passive resistance of the soil against the side of the footing. Sliding friction at the bottom of the footing can be taken at 0.42 if founded on properly compacted engineered fill.

An imported granular wall backfill material may be utilized to reduce the lateral pressures exerted on the walls. If an imported granular material is used as backfill, the granular wall backfill should extend laterally behind the wall a minimum distance equal to one half (1/2) the wall height to prevent the laterally heavier on-site cohesive soils from exerting lateral forces on the wall. The upper 6 to 8 inches of wall backfill should consist of on-site cohesive soils to limit moisture ingression into the granular backfill. If the granular wall backfill extends laterally behind the wall a distance less than one half (1/2) the wall height, the retaining structure or wall should be designed for the lateral earth pressures for the on-site soils. Imported granular wall backfill should have an internal angle of friction of no less than 32 degrees.

We recommend that foundation walls, vaults and retention structures at the site be designed for soil parameters and lateral earth pressures calculated based on the equivalent fluid pressures presented in Table 4.

Table 4 – Equivalent Fluid Pressures

	Drained Conditions	
Parameter	**On-Site Soils***	***Imported Granular Backfill****
Active, pcf	55	35
At-Rest, pcf	75	55
Passive, pcf	235	390
Friction Angle, degrees	20	32
Soil Moist Unit Weight, pcf	115	120
Cohesion, psf	0	0

Notes: *Pressures recommended for on-site soils apply to in-place native lean clay soils.
**The pressures recommended for imported granular backfill are contingent on the material demonstrating an internal angle of friction of at least 32 degrees.

An upward sloping backfill surface or the buildup of water behind a wall will increase the earth pressures on foundation and retaining walls. To prevent the buildup of water behind the walls designed for drained conditions, we recommend that the backfill immediately behind the wall consist of a free draining granular material or that a synthetic drainage material be installed between the wall and backfill materials. A wall drain system should be designed at the base of the wall to collected and convey water from the wall system. Wall backfill should be compacted in accordance with the criteria provided in Table 3. The upper 6 to 8 inches of wall backfill should consist of on-site cohesive soils to limit moisture ingression into the granular backfill.

Care should be taken not to over compact the backfill behind the walls as this could cause excessive lateral pressures on the walls. Some settlement of deep wall backfills will occur even if the material is placed correctly. All foundation and retaining structures should be designed for surcharge pressures such as adjacent traffic and construction materials and equipment. *The lateral earth pressures provided herein are unfactored. An appropriate factor of safety should be applied to retaining wall system design.*

5.5 EXTERIOR CONCRETE FLATWORK

Due to the expansive nature of the site soils, concrete flatwork at the site may experience some degree of movement as the subgrade soils are exposed to moisture variations. The extent and magnitude of the movements are difficult to predict and are largely a function of natural variations in soil mineralogy, proper drainage around and within the flatwork, proper maintenance of the flatwork and ultimately the degree to which the subgrade soils are exposed to moisture variations. We have the following suggestions to mitigate and manage potential movements of the flatwork; however, implementation of these suggestions will not necessarily eliminate movements of the flatwork.

1. We recommend that an engineered fill section a minimum of 12 inches thick be constructed below the concrete flatwork adjacent to building entryways, at stoops and at areas sensitive to tripping hazards. The engineered fill section at entryways should extent below the limits of the stoop or extend 3 feet laterally and 5 feet perpendicularly from the entryway in areas of extended concrete flatwork. The over-excavation subgrade should be sloped at minimum of 1% to drain toward an

underdrain which connects to the foundation underdrain system. The engineered fill, meeting the requirements outlined in Section 5.3.1 of this report, should be compacted in accordance with the soil compaction criteria provided in Table 3. The engineered fill section will serve to mitigate movements of the flatwork but may not eliminate all risk of movement. Figure 3 illustrates a typical frost-resistant stoop detail.

2. Concrete flatwork should be doweled into the building foundation at building entryways to minimize differential movements.

3. Positive drainage should be maintained around and within the flatwork. In no case should water be allowed to pond or collect near or within the flatwork. Downspouts should be designed to discharge a minimum of 10 feet past the limits of the building.

4. Construction and expansion joints should be sealed to prevent water infiltration to the subgrade.

5. A regular maintenance program should be implemented to identify and repair any differential movements of the flatwork. Sealed construction and expansion joints should be maintained.

6. Irrigation of vegetation within the flatwork should be limited to the minimum amount required to sustain the vegetation. Excessive irrigation will result in movements of the flatwork.

7. For areas of sidewalk or flatwork sensitive to tripping hazards, reinforcement of joints should be considered to mitigate differential movements. We recommend a minimum sidewalk thickness of 4 inches and a minimum aggregate base thickness of 2 inches.

8. Final compaction testing of the flatwork subgrade should be performed immediately before concrete placement to determine the integrity of the materials. Any subgrade material that becomes disturbed, desiccated, or does not conform to the moisture content and compaction requirements indicated in Table 3 should either be removed and replaced, or reworked to meet these recommendations.

5.6 EXCAVATIONS, SHORING AND SITE GRADING

5.6.1 Excavations and Shoring

Shallow excavations at the site will likely encounter silt and clay materials and possibly gravel, cobbles, and boulders. Where encountered, the cobbles and boulders may require additional effort to excavate. Due to the depositional nature of the site soils, the specific material types and engineering characteristics will vary both horizontally and vertically throughout the project. Observations being presented were made during limited subsurface investigations and should be used for general planning purposes. Project plans and specifications should be referred to for contract requirements regarding excavation.

Regarding excavations at the sites, we recommend that they be sloped or shored in accordance with OSHA regulations, and to generally maintain adequate safety provisions on the jobsite. The near surface clay soils can be considered OSHA Type C soils. It is the contractor's responsibility to maintain job-site safety, and the occasional or longer-term presence of an FMG, Inc. representative at the site does not constitute a review or a responsibility regarding safety aspects.

Relics of past site development may be encountered during excavations at the site. If soft conditions, debris, trees, roots, fills, utilities, and other relics associated with past site developments are encountered during excavations, such items should be removed and resulting voids should be backfilled with properly compacted engineered fill meeting the material and compaction requirements of Section 5.3 of this report. The Geotechnical Engineer should observe over-excavations prior to engineered fill placement.

5.6.2 Site Grading

Site grading for the project is anticipated to be minor. Excavations and shoring recommendations for the site grading efforts are provided in Section 5.6.1 and fill placement recommendations are provided in Section 5.3. We have the following general recommendations about site grading.

1. Any fill materials placed within structure footprints shall be considered structural subgrade and shall be compacted accordingly.

2. We recommend that all topsoil, root zones, organics, etc. be stripped in areas to receive fill or from foundation footprints.

3. Soft conditions may be encountered during site grading. If soft conditions are encountered during site grading, stabilization may be necessary to allow proper construction. Stabilization efforts should be as directed by the Geotechnical Engineer based upon site observations.

4. Site grading should provide for positive drainage away from the structure. Preventing moisture ingression to the structure subgrade soils will be critical to foundation and slab performance.

5.7 GENERAL DESIGN AND CONSTRUCTION PROVISIONS

In many cases, foundation failures and movements are associated with changes in moisture conditions. To reduce the potential of foundation and floor system failures and movements at the site, we suggest implementing construction procedures that limit the potential of subgrade soils experiencing substantial changes in moisture. We suggest the following minimum criteria.

1. For a minimum of 8 feet away from the structure, we suggest maintaining a minimum of a 5% slope for soil surfaces and a 2% slope for asphalt and concrete paving. Maintain positive drainage beyond 8 feet from the structure.

2. To prevent the retention of water near the building, we do not recommend the use of a gravel or rock mulch mow strip around the building perimeter. If a mow strip is desired, it should be a solid concrete slab which is sealed at the foundation wall. If a gravel mow strip is desired to convey storm drainage, it should be positioned at least 10 feet from the building.

3. Except for natural gas, we recommend burying all utilities at a minimum depth of six (6) feet below finished grade to receive protection from frost penetration.

4. We suggest pressure testing of all utility lines prior to backfilling to determine that there are no leaks in the system.

5. We suggest that the maintenance manager be made aware of the importance of limiting moisture ingression into the foundation soils.

5.8 GRAVEL SURFACING PARKING LOT

After stripping of topsoil and organic materials and/or the placement of fill materials, any access road or vehicle traffic area subgrade within the substation yard should be scarified to a minimum depth of 8 inches, moisture conditioned and recompacted in accordance with the compaction criteria provided in Table 3 prior to placement of any aggregate surfacing.

Due to the generally stiff shallow subgrade conditions of the site, we recommend a minimum of 4 inches of aggregate subbase and aggregate surfacing be placed throughout the parking lot area. In planned vehicle traffic areas, we recommend a minimum section of 2 inches of aggregate base and 2 inches of aggregate surfacing be utilized. The aggregate base and aggregate surfacing should be compacted in accordance with the compaction criteria provided in Table 3.

6. PROJECT OBSERVATION AND CONSTRUCTION QUALITY ASSURANCE

As the provider of the geotechnical recommendations contained herein, FMG should be retained to provide any necessary pre-construction geotechnical reviews, interpretations, and supplemental information.

If any changes in the nature, design or location of the project are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed, and conclusions of this report modified or verified in writing.

Frequently, soil conditions vary slightly from those encountered in the borings that were drilled. Therefore, FMG should be retained to review the portions of the plans that pertain to earthwork and foundations.

Additionally, proper placement of site fill, engineered fill, and other structural elements per our recommendations and per the project specifications is essential to the performance of the foundation and floors of the structure. Failure to properly place the construction materials and structural elements can result in excessive movements potentially leading to failure and significant impact to the structural integrity of the structure.

We suggest the following minimum standards and frequency of testing be followed for soil and concrete construction materials placed at the project site.

Table 5 – Recommended Frequency of Testing

Material or Placement Location	*Recommended Standard or Frequency*
Structural Concrete	ACI 318 Chapter 26.12
General Site Fill	1 test per 12” lift per 10,000 ft^2
Foundation and Slab Excavation Subgrade	1 test per 500 ft^2
Engineered Fill Below Foundations and Slabs	1 test per 12” lift per 500 ft^2
Foundation Backfill	1 test per 75 linear feet per vertical foot
Utility Trench Backfill	1 test per 24” lift per 200 linear feet
Pavement Subgrade	1 test per 2,500 ft^2

Our recommendations are based on the necessary assumption that the material and structural element placement will occur as specified and that a detailed construction quality assurance program will be provided that clearly documents the proper placement of materials and structural elements at this site through adequate methods and frequency of testing. In the absence of such quality assurance and documentation, FMG cannot assume responsibility or liability for the performance of any foundation systems, embankments, or structural elements of this project. Should another agent perform the construction quality assurance, said agent will necessarily assume the role and responsibilities of construction-phase geotechnical engineer of record.

We are available to observe construction operations, particularly the concrete placement operations, the compaction of the fill materials, and other such field observations as may be necessary. Under no circumstances is it our intent to directly control the physical activities of the contractor or the contractor's workmen. Any field testing or observations performed by FMG would be a part of engineering opinions rendered to the contractor and should not be misconstrued as supervision of the contractor's work or workmen.

7. CONCLUDING STATEMENT

If any changes in the nature, design or location of the project features are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed, and conclusions of this report modified or verified in writing.

The findings and recommendations in this report were prepared following accepted soil mechanics procedures and practices. We make no other warranty, either implied or expressed. The conclusions and recommendations of this report are based upon the results of the field exploration boring, field tests, laboratory tests, and analysis. We have extrapolated the data obtained from the test borehole locations to the surrounding soils. Anomalies can exist around the borings. The data presented on the boring logs represent the conditions as encountered in that test hole on the date drilled and logged. If, during planning and construction, conditions are different from those indicated, please notify us so that we can modify the conclusions and recommendations.

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FMG ENGINEERING
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Rapid City, SD 57702
605.342.4105 • fmgengineering.com

Preliminary Not For Construction

File Number: 241471.00

Location: XXX XXX

Surveyed By: XXX
Date: XXX

Designed By: XXX
Drawn By: XXX
Checked By: XXX

January 2025

Hot Springs VA Hospital Renovate Electrical Equipment

Hot Springs, South Dakota

Revision / Date

Sheet Name:

Boreholes

Sheet Number:

Figure 1

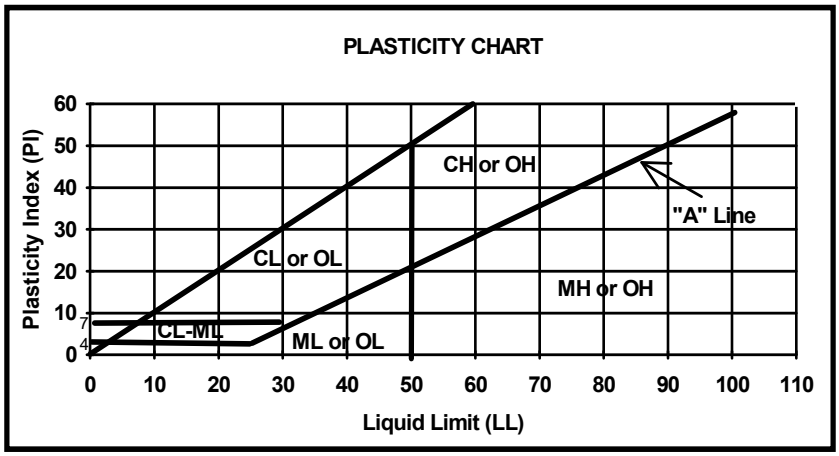
Path: Z:\241471.00 Stone Grp-Hot Springs VA Renovate Electrical Equipment\Geotech\Borehole Map.aprx - 17 x 11 Standard Boreholes - 1/14/2025 7:54 AM

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES

ASTM Designation: D 2487-90 and D 2488-90 (Unified Soil Classification System)

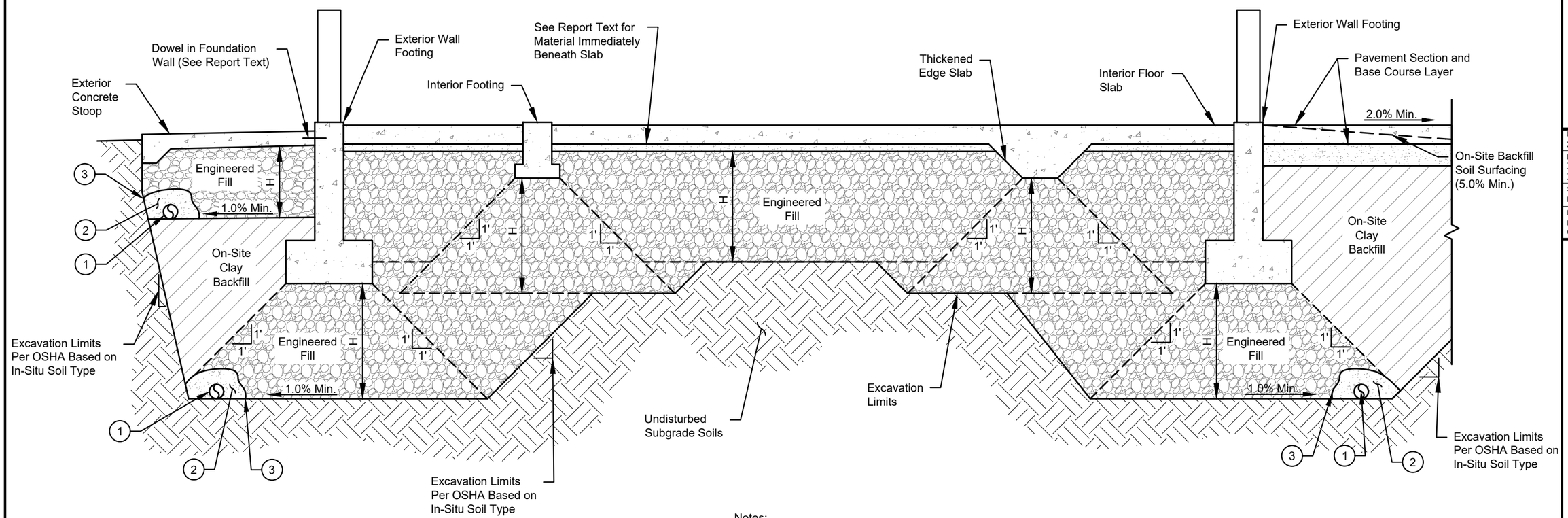
Criteria for Assigning Group Symbols and Group Names[A]				Soil Group	Classification Symbol Name
COARSE-GRAINED SOILS More than 50% retained on the No. 200 sieve	**Gravels** More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3[E]	GW	Well-Graded Gravel[F]
			Cu < 4 and/or 1 > Cc > 3[E]	GP	PoorlyGradedGravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty Gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey Gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3[E]	SW	Well-Graded Sand[I]
			Cu < 6 and/or 1 > Cc > 3[E]	SP	Poorly Graded Sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty Sand[G,H,J]
			Fines classify as CL or CH	SC	Clayey Sand[G,H,I]
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	**Silts and Clays** Liquid limit less than 50	inorganic soils	PI>7and on or above "A" line[J]	CL	Lean Clay[K,L,M]
			PI<4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	Liquid limit-oven dried / Liquid limit-not dried < .75	OL	Organic Clay[K,L,M,N]
		soils			Organic Silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic soils	PI plots on or above "A" line	CH	Fat Clay[K,L,M]
			PI plots below "A" line	MH	Elastic Silt[K,L,M]
		organic	Liquid limit-oven dried / Liquid limit-not dried < .75	OH	Organic Clay[K,L,M,P]
		soils			Organic Silt[K,L,M,Q]
HIGHLY ORGANIC SOILS		Primarily organic matter, dark in color, and organic odor		PT	Peat

A. Based on the material passing the 3-in. (75-mm) sieve.
B. If field sample contained cobbles or boulders, or both, add "with cobbles and boulders, or both" to group name.
C. Gravels with 5% to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay
D. Sands with 5% to 12% fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay
E. $Cu = D_{60}/D_{10}$ $Cc=(D_{30})^2/D_{10}xD_{60}$
F. If soil contains ≥ 15% sand, add "with sand" to group name.
G. If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM
H. If fines are organic, add "with organic fines" to group name.
I. If soil contains ≥ 15% gravel, add "with gravel" to group name.
J. If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.
K. If soil contains 15% to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
L. If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.
M. If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravely" to group name.
N. PI ≥ 4 and plots on or above "A" line.
O. PI < 4 or plots below "A" line.
P. PI plots on or above "A" line.
Q. PI plots below "A" line.



Equation of "A" - line: Horizontal at PI = 4 to LL = 25.5, then PI = 0.73(LL-20) (Chart is for general graphic presentation purposes only)

- Figure 2-



Foundation Drain Detail Callouts:

(1) Minimum 4" Diameter, Non-Corrugated, Perforated PVC Drain Pipe with 6" Minimum Layer of Free Draining Gravel Surrounding Pipe, Wrapped in 8 oz. Non-Woven Filter Fabric. Slope for Positive Drainage to Sump or Daylight.

(2) 6" Layer of Free Draining Gravel. See Geotechnical Report for Gradation Specifications.

(3) 8 oz. Non-Woven Filter Fabric

Notes:

1. Foundation drain detail applicable if indicated in geotechnical report or project plans and specifications.
2. H = Over-excavation and engineered fill depth. See geotechnical report text for specific recommendations.
3. Sketch is idealized for reference only, actual construction means and methods and field conditions may dictate width, depth and slopes of excavations. Geotechnical Engineer of record shall review and approve final design's construction. See Structural drawings and specifications for concrete and reinforcement requirements.
4. Over-excavation and engineered fill should extend at a minimum of 1:1 (horizontal:vertical) from outside edge at base of footings
5. See Fill Materials section in geotechnical report for specifications regarding engineered fill.

TYPICAL OVER-EXCAVATION, ENGINEERED FILL, FROST - RESISTANT STOOP, AND FOUNDATION DRAIN

Not To Scale

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File Number: 241471	
Location: XXX XXX	
Surveyed By:	XXX
Date:	XXX
Designed By:	XXX
Drawn By:	XXX
Checked By:	XXX

January 2025

Hot Springs VA Hospital
Renovate Electrical Equipment
Hot Springs, South Dakota

Revision / Date

Sheet Name: Typical Over-Ex, Engineered Fill, Frost-Resistant Stoop, and Foundation Drain

Figure Number: **3**

Y:\Reference Engineering Documents\Geotech Stuff\Geotechnical Details and Figures\Report Figures.dwg - Over-Ex and Drain - 11x17 - Wednesday, January 15, 2025 12:57:55 PM

Appendix A

Borehole Logs

PROJECT: Hot Springs VA Renovate Electrical Equipment

LOCATION: Rapid City, SD

PROJECT #: 241471.00

DATE STARTED: 11/8/24 **COMP.:** 11/8/24

CONTRACTOR: FMG, Inc.

DRILL METHOD: HSA Diedrich D70

GEOLOGIC LOG OF BOREHOLE 1

FMG ENGINEERING
605-342-4105
3700 Sturgis Road
Rapid City, SD 57702
fmgengineering.com

BORING LOCATION: Inside lot

GROUND ELEVATION:

DATUM:

BORING DIAMETER: 6 5/8

COLLAPSE DEPTH: n/a

FILL DEPTH: n/a

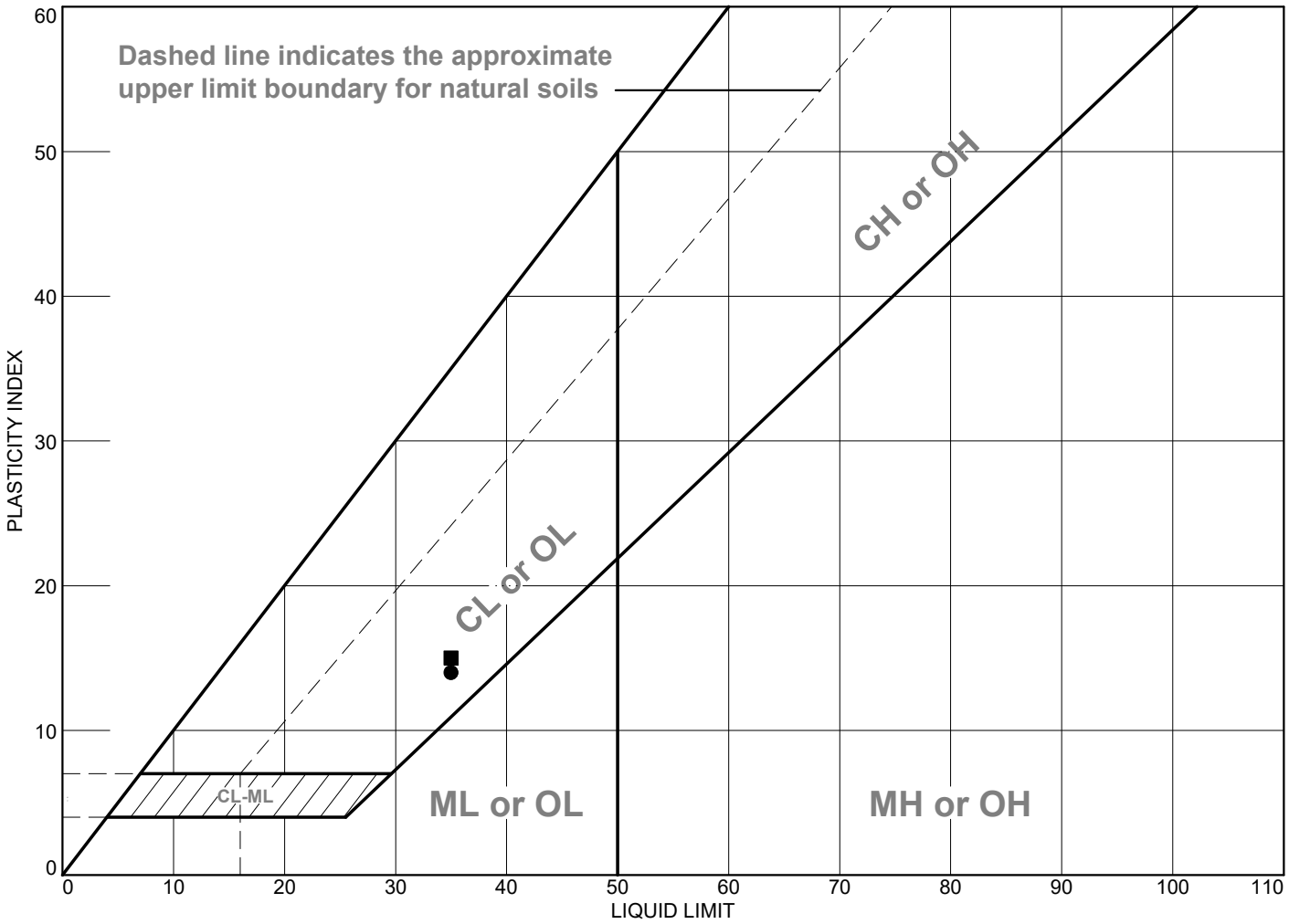
ELEVATION / DEPTH	WATER	GEOLOGY GRAPHIC	Sample Info Type,#/Blows	USCS	DESCRIPTION	NM %	DD (pcf)	LL (%)	PI (%)	Qu (psf)	phi (deg)	Swell (%) (ksf)
0		Terrace Deposit		Tops	Grass and Topsoil: 3 inches in thickness.							
				CL-ML	Silty Lean Clay: Brown, dry to moist, low plasticity, medium stiff to stiff.							
			S1A	CL		10.0	106.7	35	14	13242		1.0 1.0
5			P1A 6/5/6 N=11	CL		20.2		35	15			
10			P1B 7/17/19 N=36	GM	Silty Gravel with Sand: Brown, dry, non-plastic, dense to very dense.							
15			P1C 34/ BNCE N=100									
20			P1D 9/10/18 N=28	GM		5.0		NV	NP			
					- End of borehole at 21.5 feet. No groundwater encountered while drilling.							
25												
30												
35												

SEE ATTACHED KEY FOR ABBREVIATIONS, NOTES & DESCRIPTIONS

Appendix B

Laboratory Testing

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Silty Lean Clay: Brown, dry to moist, non-plastic, dense.	35	21	14	97.3	87.6	CL
■	Silty Lean Clay: Brown, dry to moist, non-plastic, dense.	35	20	15	98.9	88.1	CL
▲	Silty Gravel with Sand: Brown, dry, non-plastic, very dense to hard.	NV	NP	NP	36.8	25.8	GM

Project No. 241471.00 **Client:** Stone Group

Project: Hot Springs VA Renovate Electrical Equipment

● **Source of Sample:** 1 **Depth:** 3.5 **Sample Number:** S1A

■ **Source of Sample:** 1 **Depth:** 5 **Sample Number:** P1A

▲ **Source of Sample:** 1 **Depth:** 20 **Sample Number:** P1D

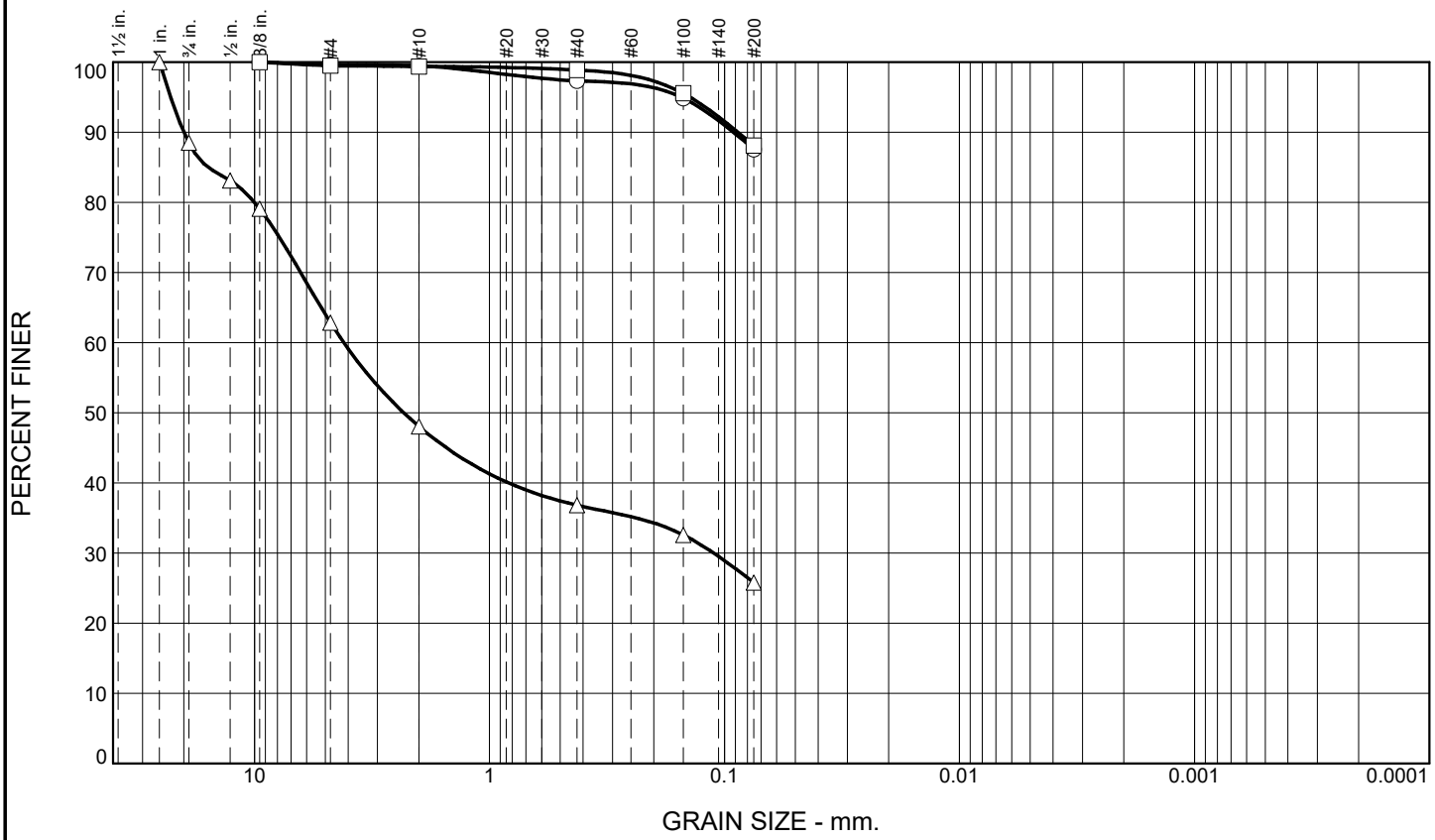
Remarks:

FMG, Inc.

Figure

Tested By: ● JB ■ CA ▲ JB **Checked By:** JB

Particle Size Distribution Report



	+3"	% GRAVEL	% SAND	% SILT	% CLAY	USCS	LL	PL	PI
○	0.0	0.4	12.0	87.6		CL	35	21	14
□	0.0	0.5	11.4	88.1		CL	35	20	15
△	0.0	37.2	37.0	25.8		GM	NV	NP	NP

SIEVE inches size	PERCENT FINER ○	□	△
1			100.0
3/4			88.5
1/2			83.1
3/8	100.0	100.0	79.1
GRAIN SIZE			
D_{60}			4.1719
D_{30}			0.1112
D_{10}			
COEFFICIENTS			
C_c			
C_u			

SIEVE number size	PERCENT FINER ○	□	△
#4	99.6	99.5	62.8
#10	99.5	99.4	48.1
#40	97.3	98.9	36.8
#100	94.8	95.5	32.6
#200	87.6	88.1	25.8

Material Description

○ Silty Lean Clay: Brown, dry to moist, non-plastic, dense.

□ Silty Lean Clay: Brown, dry to moist, non-plastic, dense.

△ Silty Gravel with Sand: Brown, dry, non-plastic, very dense to hard.

REMARKS:

○ F.M.=0.12

□ F.M.=0.09

△ F.M.=3.70

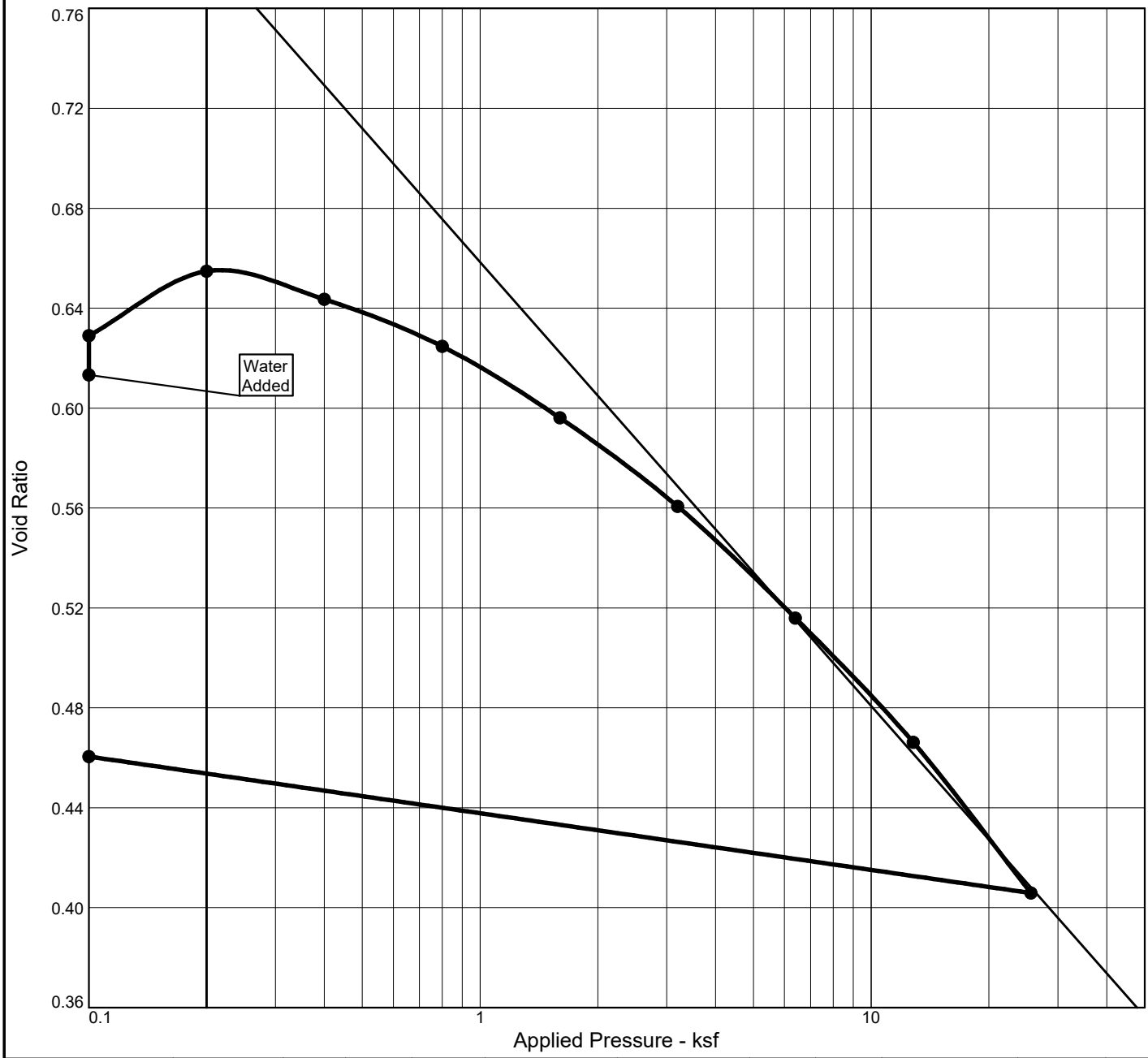
○ Source of Sample: 1 Depth: 3.5 Sample Number: S1A
□ Source of Sample: 1 Depth: 5 Sample Number: P1A
△ Source of Sample: 1 Depth: 20 Sample Number: P1D

FMG, Inc.

Client: Stone Group
Project: Hot Springs VA Renovate Electrical Equipment
Project No.: 241471.00 Figure

Tested By: ○ JB □ CA △ JB **Checked By:** JB

CONSOLIDATION TEST REPORT



Natural Sat.	Natural Moist.	Dry Dens. (pcf)	LL	PI	Sp. Gr.	Overburden (ksf)	P_c (ksf)	C_c	C_s	Swell Press. (ksf)	Swell %	e_o
42.9 %	10.0 %	102.2	35	14	2.65	.5	1.0	0.18	0.02	1.0	1.0	0.619

MATERIAL DESCRIPTION	USCS	AASHTO
Silty Lean Clay: Brown, dry to moist, non-plastic, dense.	CL	A-6(12)

Project No. 241471.00 **Client:** Stone Group

Project: Hot Springs VA Renovate Electrical Equipment

Source of Sample: 1 **Depth:** 3.5 **Sample Number:** S1A

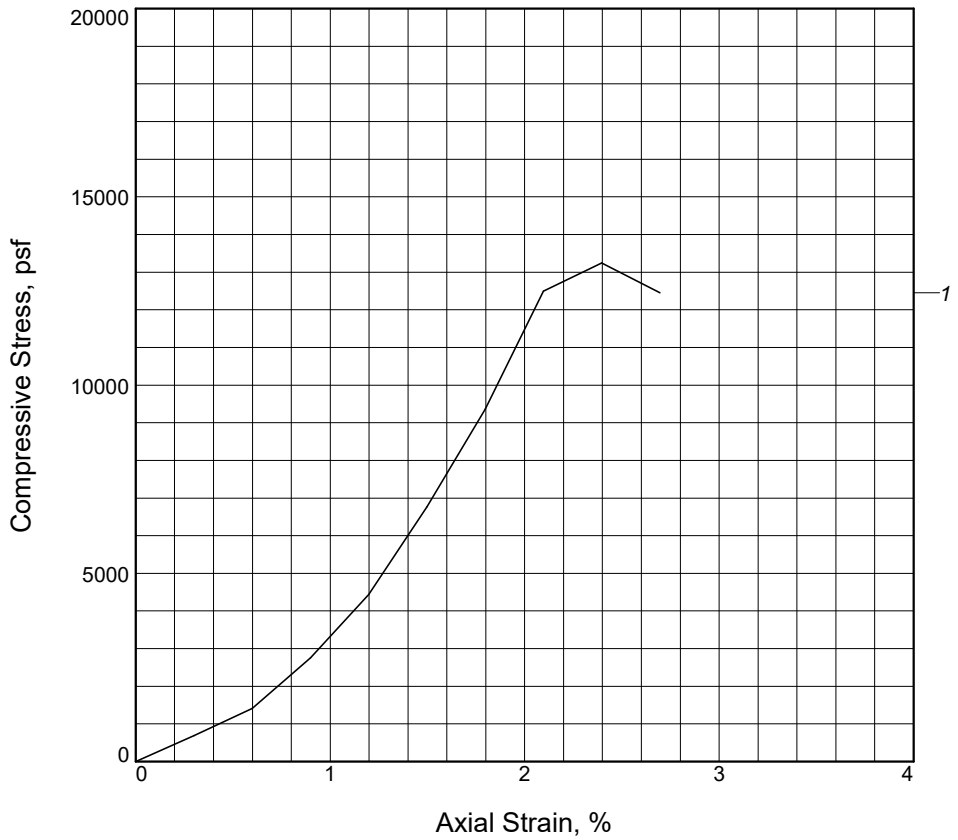
Remarks:

FMG, Inc.

Figure

Tested By: JTL **Checked By:** JTL

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	13242			
Undrained shear strength, psf	6621			
Failure strain, %	2.4			
Strain rate, in./min.	0.030			
Water content, %	10.0			
Wet density, pcf	116.7			
Dry density, pcf	106.1			
Saturation, %	47.5			
Void ratio	0.5592			
Specimen diameter, in.	2.87			
Specimen height, in.	3.34			
Height/diameter ratio	1.16			

Description: Silty Lean Clay: Brown, dry to moist, non-plastic, dense.

LL = 35	**PL =** 21	**PI =** 14	**Assumed GS=** 2.65	**Type:** Shelby

Project No.: 241471.00
Date Sampled: 11/8/24
Remarks:

Client: Stone Group

Project: Hot Springs VA Renovate Electrical Equipment

Source of Sample: 1 **Depth:** 3.5
Sample Number: S1A

FMG, Inc.

Figure _____

Tested By: JB **Checked By:** JB

Appendix C

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